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Circular No. 878

Pests of Sugarcane and Their Control

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Division of Cereal and Forage Insect Investigations
Bureau of Entomology and Plant Quarantine
Agricultural Research Administration

UNITED STATES DEPARTMENT OF AGRICULTURE

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Pests of Sugarcane and Their Control

By J. W. Ingram, E. K. Bynum, and Ralph Mathes, *entomologists*, W. E. Haley, *scientific aid*, and L. J. Charpentier, *entomologist*, *Division of Cereal and Forage Insect Investigations*, *Bureau of Entomology and Plant Quarantine*, *Agricultural Research Administration*

CONTENTS

- Sugarcane borer — 2
  - Nature and extent of damage — 2
    - Dead hearts in young plants — 2
    - Dead tops in older plants — 3
    - Broken-over stalks — 3
    - Loss in weight and sucrose — 3
    - Injury to seed cane — 4
  - Crop losses from borer injury — 4
  - Description of stages — 5
  - Life history and habits — 5
  - Natural control — 7
  - Artificial control — 8
    - Destruction of overwintering borers — 8
    - Cutting out and destroying borers in dead hearts — 12
    - Control with insecticides — 12
    - Planting resistant varieties — 14
    - Selecting the least infested cane for seed — 17
    - Miscellaneous control measures — 17
- Sugarcane beetle — 18
  - Nature and extent of injury — 18
- Sugarcane beetle—Continued
  - Life history in Louisiana — 20
  - Natural control — 20
  - Control measures — 21
- Gray sugarcane mealybug — 22
- Sugarcane weevil — 23
- Wireworms — 24
  - Control — 25
- West Indian sugarcane fulgorid — 26
- West Indian sugarcane mite — 27
- Lesser cornstalk borer — 27
- Fall armyworm — 28
- Small soil animals that attack sugarcane roots — 31
- Insects that transfer sugarcane diseases — 33
- Other insects attacking sugarcane — 35
- Warning against moving untreated sugarcane from one State to another — 37
- Precautions in the use of insecticides — 37
- List of common and scientific names of insects — 38

Pests of sugarcane cause enormous losses annually to this important crop in the United States. Damage by the sugarcane borer alone has been estimated at more than $6,000,000 in some years. The most important pests of the crop in this country and the best-known means for their control are discussed in this circular.

SUGARCANE BORER

The sugarcane borer [1] is the most injurious insect attacking sugarcane in the United States. It is found in Florida south of the latitude of Daytona; in Mississippi in a strip 20 to 50 miles wide along the Gulf coast, and in a small area around Centreville; in Louisiana south of a line west from Bougere through Coushatta to Zwolle; and in a strip of Texas 50 to 150 miles wide bordering the Gulf. It has not been found in Georgia or Alabama. The extent of the infested area has changed little in recent years.

Nature and Extent of Damage

Borer attacks on sugarcane may cause any of the following types of damage: (1) Dead hearts in young plants, (2) dead tops in older plants, (3) broken-over stalks, (4) loss in weight and sucrose, and (5) injury to seed cane.

Borer injury is not so easily recognized in old plants as in young ones unless the infestation is heavy enough to cause many dead tops and broken stalks. Some borers, as they tunnel up and down the stalk, gnaw their way out through the hard rind and re-enter at another place. Usually the leaf sheaths must be stripped off to detect borer entrance and exit holes and the sawdustlike frass pushed out of borer tunnels.

DEAD HEARTS IN YOUNG PLANTS

The injury known as dead hearts may be recognized by the yellow, dying condition of the inner whorl of leaves in contrast to the healthy, green outer and lower leaves. Similar dead hearts also result from the feeding of adults of the sugarcane beetle, wireworms, and larvae of the lesser cornstalk borer, as well as from cuts made by cultivators and hoes, and from injuries caused by men or animals stepping on the young plants. Sometimes even a twisted growth of the inner tissues will cause dead hearts. If the plant is cut and examined, borer injury may be distinguished from mechanical injuries by the tunnels and frass and usually by the presence of the borer itself. Where borer infestation is moderate to heavy and wireworms or sugarcane beetles are not abundant, the sugarcane borer is usually responsible for about 85 percent of the dead hearts.

The injury develops as follows: Moths from overwintering borers deposit eggs on the leaves of the young cane plants. The young borers hatching from these eggs feed on the leaves for a few days and then bore into the plant, where they feed on the central tissues. Thus the growing shoot is gradually cut off and dies. As a result of cannibalism and other causes, usually only one borer reaches maturity in each dead heart. In Louisiana first-generation borers cause dead hearts in about 95 percent of the shoots attacked. Some dead hearts result from injury by borers of later generations, but seldom after the stalks have formed joints.

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[1] The scientific names of the insects discussed in this circular are given on p. 38.

It is difficult to determine losses from dead hearts. Most of the injured plants do not die but form new shoots. As these shoots are less mature at harvesttime than the original stalks would have been, there is certainly some loss in sucrose. In stubble cane in Louisiana as many as 4,347 dead hearts per acre caused by first-generation borers, or about 11 percent of all the plants present at the time of infestation, have been observed.

DEAD TOPS IN OLDER PLANTS

In older plants borers attacking the stalk near the top cut off the flow of food substances to that portion of the plant and it dies. As a result many of the lower buds may sprout. Not only does the growth of these sprouts decrease the sucrose content of the old stalk, but the sprouts themselves are usually too low in sucrose at harvesttime to be of any value.

BROKEN-OVER STALKS

Borers tunneling in the stalks or encircling them when they reach the hard tissue at the nodes often so weaken the supporting tissues that the upper part of the stalk falls over or is broken over by the first strong wind (fig. 1). When the break occurs near the ground the broken-over stalk may be left in the field during harvest and buds on the lower part of the stalk may sprout and grow.

LOSS IN WEIGHT AND SUCROSE

The consumption of plant tissue by the borers and the cutting of vessels that carry plant food reduce the weight and growth of the cane. Borer injury also lessens the amount of juice that can be extracted from the stalk and the percentage of solids and sucrose in this juice. The purity of the juice is correspondingly lowered, and the percentages of reducing sugars, ash, gums, alcohol-precipitable nonsugars, and total organic nonsugars are increased. The color of the clarified juices and sirups is darkened and their turbidity is increased by borer injury. This deterioration resulting from borer injury is increased by the entrance of red rot, other fungi, and bacteria into the borer tunnels. Borer injury also retards the maturity of affected stalks. It is generally considered that bored cane does not keep so well after it is cut for milling as sound cane does.

On the basis of analyses of infested and clean cane made in several cane-growing countries, the loss of sucrose in infested canes is estimated to be from 10 to 20 percent. From sucrose analyses of bored and nonbored cane made at Houma, La., in 1939, it was estimated that for the varieties Co. 281, C. P. 28/19, and C. P. 29/320, a 10-percent loss in sucrose resulted when 20 percent of the joints were bored. According to annual harvesttime surveys of the Louisiana cane-growing area, conducted in cooperation with the Louisiana Agricultural Experiment Station, the percentages of joints bored have been as follows: 1935, 8; 1936, 9; 1937, 16; 1938, 16; 1939, 20;

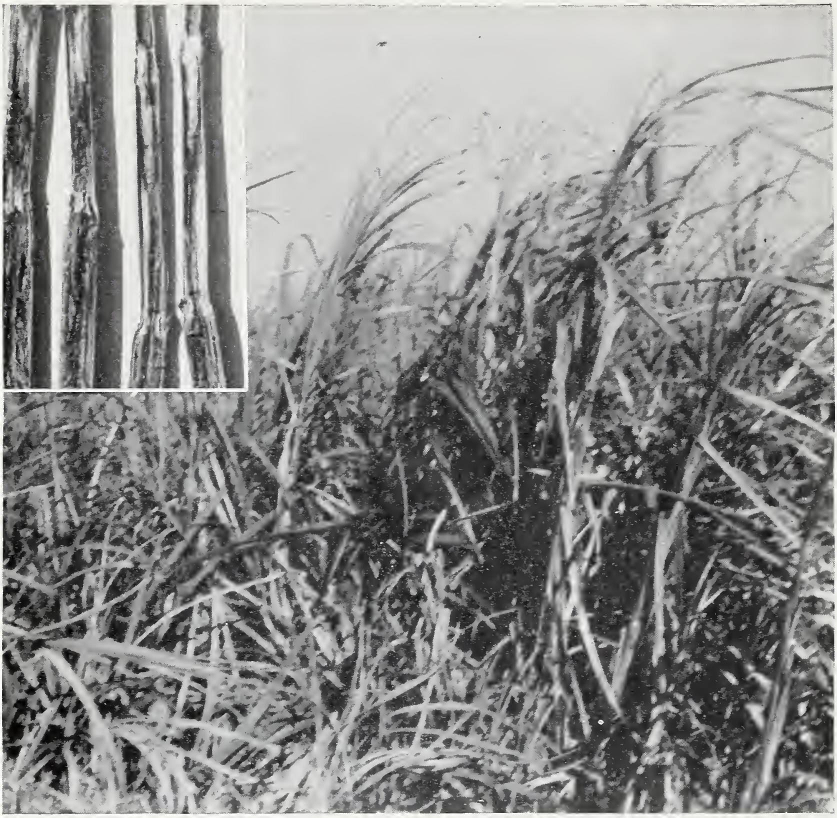

Figure 1.—Portion of sugarcane field showing heavy injury by sugarcane borer. Note the broken tops and stunted uneven growth caused by borers. Insert shows cane stalks injured by borer tunnels.

1940, 5; 1941, 20; 1942, 24; 1943, 19; 1944, 14; 1945, 17; 1946, 10; 1947, 13; 1948, 9; 1949, 23; and 1950, 13.

INJURY TO SEED CANE

In Louisiana seed cane is planted late in the summer or in the fall and is therefore subject to heavy deterioration during wet winters because the planted stalks are very susceptible to red rot and other rots during this dormant period of low temperatures. Borer tunnels in the cane increase this hazard, especially in any variety that is susceptible to red rot. If badly bored seed cane of such a variety is planted, the losses may be serious.

Crop Losses From Borer Injury

Total losses from sugarcane borer injury to sugarcane, corn, rice, sorghums, and a number of wild grasses in continental United States have been estimated at over $10,000,000 annually. In all these crops the borer tunnels inside the stalks, stunting the growth and sometimes killing the upper part of the plant. These tunnels provide ideal places for the entrance and spread of some disease organisms that attack the host plant.

In Louisiana for the period 1912 to 1950, inclusive, crop losses of sugarcane have ranged from 4 to 30 percent annually. In 1950 the loss was estimated at about 630,000 tons of cane valued at $5,700,000. The loss in southern Florida is about half that in Louisiana, as the borer infestation is about half as severe. Borer injury is usually much greater in cane grown on light soils than in that grown on heavy soils, and, except in hill sections, it is usually greater on the higher and better-drained lands. Injury by first-generation borers in the spring is usually much greater in stubble cane than in cane planted the previous fall. This difference in infestation becomes smaller as the season advances, so that by harvesttime the plant-cane and stubble-cane infestations are about equal.

Description of Stages

The adult of the sugarcane borer is a straw-colored moth (fig. 2, *D*) having each forewing marked with black dots in a V-shaped design. The size of the moth varies with the amount of food taken by the larva, but averages an inch or slightly more from tip to tip of the spread wings.

The eggs (fig. 2, *A*) are flat and elliptical and about 1.16 mm. long. They are deposited in flat clusters on the leaf and overlap one another like fish scales. The clusters contain from 2 to 100 or more eggs, although the number averages about 25 and is usually less than 50. The eggs are creamy white when laid but become more yellowish as the incubation period advances, until the curled bodies of the young borers may be seen through the eggshell.

The larva (fig. 2, *C*) is about 1 inch long when full-grown. It is yellowish white with brown spots, although in the winter these spots are often absent and the color becomes a deeper yellow.

The pupa, or resting stage, (fig. 2, *B*) is light to dark brown and about ⅗ inch long and ⅙ inch wide.

Life History and Habits

The sugarcane borer overwinters as a larva within a tunnel it has made in its host plant. Early in the spring the larva becomes active and extends its tunnel toward the surface of the stalk. Here the larva transforms to a pupa, from which the adult moth soon emerges. After mating, the female moth deposits eggs on the leaves of host plants. In 4 to 9 days these eggs hatch into tiny larvae, which feed for a short time on the leaf or in the central whorl and then bore into the stalk. They also tunnel up and down the stalk, occasionally coming out to re-enter at some other point. At the end of 20 to 30 days in the summer the larvae transform to pupae within the tunnel, and 6 or 7 days later the moths emerge. There are four or five generations annually.

With the approach of cool weather in the fall the borer larvae become more sluggish and feed only on warm days. In Louisiana, Texas, and Mississippi borers begin to hibernate in September and

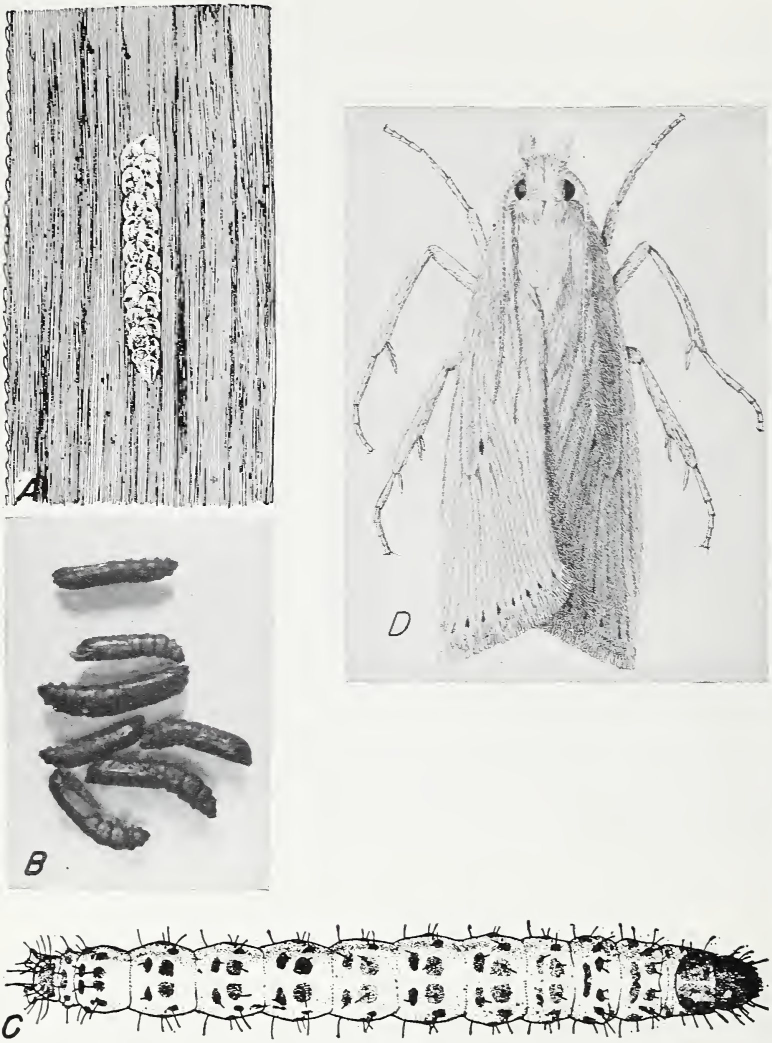

FIGURE 2.—Sugarcane borer: *A*, Cluster of eggs nearly ready to hatch; *B*, pupae; *C*, larva, dorsal view; *D*, adult with wings folded. Enlarged.

October, and the moths emerge the following April. In southern Florida borers go into hibernation about a month later and the moths emerge a month earlier. Cane trash left on the field after harvest, young plants of summer-planted cane, seed cane, cane stubble, and wild grasses are preferred for hibernation quarters and are listed in the order of their importance. In rice-growing areas many of the borers hibernate in rice stubble. The number hibernating in corn is in proportion to the corn's lateness in maturing. Very few borers hibernate in early planted corn.

Natural Control

The weather affects borer abundance. Fewer borers survive the winter if there are abnormally low temperatures and heavy rainfall. Late freezes in the spring, after the overwintered borers have become active, help to curtail infestations. Heavy rains wash some borer eggs and young larvae from the plants. On the other hand, periods of dry weather kill some of them.

A minute wasp, *Trichogramma minutum* Riley, which is found almost everywhere, also helps to decrease borer injury. This parasite deposits its eggs in those of the borer. The parasite larva eats the contents of the borer egg, and usually in about 8 days the adult *Trichogramma*, instead of a borer larva, emerges from the egg. Parasitized eggs are readily distinguished, as they turn black in 3 or 4 days.

Only a few borer eggs of the first generation are parasitized by *Trichogramma minutum*. The percentage increases, however, with each succeeding generation of the borer until in many Louisiana sugarcane fields during September and October more than 90 percent of the eggs may be parasitized. It was formerly thought that *T. minutum* hibernated in trash left in sugarcane fields after the harvest and that the burning of trash killed many of the parasites. However, large-scale experiments conducted over a period of several years have proved that the burning of trash does not affect the percentage of parasitization the following season.

Trichogramma minutum would be much more beneficial if it were present in larger numbers early in the season. Attempts have been made to increase its usefulness as a parasite of the sugarcane borer, as well as of other host species, by breeding and releasing it in large numbers early in the year. Large numbers have been reared on eggs of the Angoumois grain moth and released in sugarcane fields from May to August, when natural parasitization is low and borer eggs are on the plants. Large-scale experiments to determine the value of such mass liberations of *Trichogramma* as a control for the borer were conducted in Louisiana in 1933, 1934, and 1935. Areas in which parasites were released showed no increase in parasitization of borer eggs, no decrease in infested joints or stalks, and no increase in weight of cane per acre, in sugar per ton of cane, or in pounds of sugar per acre over similar areas in which no parasites were released. Therefore, colonization of this parasite as a method for borer control is not recommended. No way of increasing the effectiveness of *Trichogramma* against the borer is known.

Other native parasites that have been found attacking the borer have not appeared in sufficient numbers to be of appreciable value in controlling it.

Fourteen parasitic insects known to attack the sugarcane borer or related species in foreign countries and in some sections of the United States have been introduced into the region where the borer is present. Only two of these parasites—a fly, *Lixophaga diatraeae* (Towns.), and a wasplike insect, *Bassus stigmaterus* (Cress.)—have proved of value. Although they have not survived elsewhere in the United States in sufficient numbers to be of value in borer control, they are fairly common in southern Florida. A survey made at Fellsmere, Fla., in cooperation with the Everglades Experiment Station in

December 1946, showed that 76 percent of the borer larvae had been parasitized by one of these species. The percentages of parasitization at harvesttime by these two species at Fellsmere in more recent years were as follows: 1 in 1947, 60 in 1948, 10 in 1949, and 20 in 1950. The low percentages of parasitization were often the result of light borer infestations following very heavy parasitization.

Ants sometimes attack various stages of the borer, but their value in borer control is more than offset by the increase in mealybugs and aphids which results from their husbanding of these insects. Adults and larvae of a soldier beetle, *Chauliognathus marginatus* F., are occasionally found attacking borer larvae. Earwigs feed on both eggs and larvae, and the large numbers of these predators in Florida indicate that they may be of much value in borer control there.

Birds are undoubtedly of much value in borer control. The Federal Fish and Wildlife Service lists the following birds as feeding on members of the family Pyralidae, to which the sugarcane borer belongs:

Eared grebe
Mallard
Black duck
Wood duck
Canvasback
Road runner
Tree swallow
Blue jay
Florida jay
Canada jay
Common crow
Bufflehead
Hungarian partridge
Bobwhite
Gambel's quail
Scaled quail
House wren
Mockingbird
Robin
Starling
Palm warbler
English sparrow
Sage grouse
Ring-necked pheasant
Wild turkey
Spotted screech owl
Nighthawk
Meadowlark
Red-winged blackbird
Baltimore oriole
Savannah sparrow
Cape Sable seaside sparrow

Fungi and bacteria have been found attacking borer larvae and pupae, but their attacks usually follow other injury to the borer. These organisms probably provide little control.

Artificial Control

DESTRUCTION OF OVERWINTERING BORERS

Populations of the sugarcane borer are lowest in the spring because a large number die during the winter. The estimated number of borers that survive the winter in Louisiana in various materials, based on large numbers of field counts over a period of several years, are as follows:

	Maximum	*Average*
Sugarcane:		
Stubble	89	37
Fall-planted seed cane	126	48
Summer-planted seed cane	33	12
Fall-planted young shoots	0	0
Summer-planted young shoots	15, 246	877
Burned trash	1, 742	189
Covered nonburned cane trash	3, 744	870
Rice stubs	84, 942	42, 471

Cane trash left on the field after harvest is the most important source of borers that infest the new growth the following spring. Practically all borers overwintering in cane trash do so in pieces of millable cane (fig. 3). Thorough clean-up of these pieces during harvesting operations greatly reduces the number of borers overwintering in such material. A man with a cart can pick up enough millable scrap cane behind the loader to pay for the operation. Combined piler-loaders leave less cane in the field at harvesttime, and consequently fewer borers to overwinter, than when separate implements are used for piling and loading.

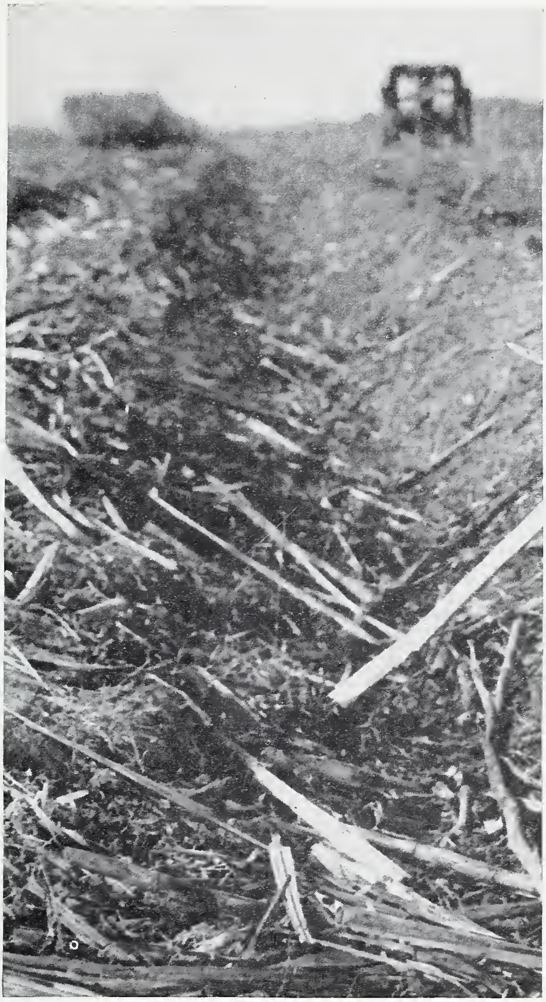

FIGURE 3.—Millable cane left in the field after harvest. Borers overwinter in such cane in large numbers.

Cane leaves left in the fields after harvest help to protect the borers in the trash. Burning this trash destroys approximately three-fourths of the borers overwintering in it. The effect of such disposal has been apparent in the reduction of first-generation injury, even in small plots. More than twice as many dead hearts, resulting from injury by first-generation borers, were present in fields where trash from the previous harvest had not been burned, but plowed under, as in fields where the trash was burned. It is therefore recommended that the trash be burned as thoroughly as possible.

If equal borer control could be obtained without burning the trash, and if the mechanical difficulties involved in otherwise disposing of the large volume present in the fields could be overcome, it would undoubtedly be preferable to use the organic material rather than burn it, for the reason that it benefits the soil and reduces soil-animal and root-rot injury. Under methods now available for trash handling, however, the trash must be burned to facilitate tillage operations and to reduce the number of overwintering borers.

Burning has not reduced parasitization by *Trichogramma minutum*. Experiments conducted over a period of 4 years showed that the percentage of parasitization in unburned fields is no higher than in burned fields, either in first-generation eggs or in eggs deposited later in the season. No borer eggs are available in sugarcane fields from harvest until moths emerge from overwintered borers the following spring. *Trichogramma* adults have always emerged in a short time from parasitized borer eggs collected in the field in the fall and held at prevailing field temperatures. It seems unlikely that the adults of *Trichogramma* hibernate in sugarcane trash, as there are always days and successions of days warm enough for activity during the winter. *Trichogramma* apparently overwinters in the sugarcane-growing areas by continuous breeding in the eggs of hosts other than the borer, and none of these hosts are known to oviposit in cane trash.

In fields where the stubble is to be retained for next year's crop the trash should be plowed under in the middles as soon as possible after burning, and not later than February. The trash and millable cane in the middles should be allowed to remain covered as long as practical cultivation will permit—up to the end of May if possible. The soil covering the trash will prevent many moths from escaping. In fields where the stubble is not to be retained, the stubbles, trash, and pieces of millable cane should be plowed under before the last of February.

Borers overwintering in cane stubble usually are found above ground or at the surface of the soil. Borer survival in cane stubble could be reduced by cutting the stalks close to the ground. The additional sucrose obtained by lower cutting would alone justify this procedure.

Although a fairly large number of borers overwinter in fall-planted seed cane, it is doubtful whether many of the resulting moths succeed in penetrating the usual 2 to 3 inches of soil lying above the cane and reaching the surface. Owing to the longer period spent underground, about one-fourth as many borers survive the winter in summer-planted seed cane as in fall-planted. Under usual soil conditions moths are unable to emerge through more than one-half inch of soil. The small number of borers that overwinter and emerge as moths from seed cane could be reduced still further by selecting seed that contains few borers. Soaking the infested cane in water at room temperature for 72 hours does not affect the cane and kills approximately 69 percent of the borers. This treatment may not be practicable on a large scale, but it is a good one to use when isolated fields of not more than 5 to 10 acres are being planted.

No borers have ever been found overwintering in shoots growing from fall-planted cane, except during the winter of 1949–50 when the shoots were not killed by freezes; but more than 15,000 borers per acre and an average of over 1,500 borers per acre for the period 1944–50 were found overwintering in shoots from summer-planted cane (fig. 4). The number of borers in such shoots may be greatly reduced by shaving summer-planted cane fields in March, plowing the shaved shoots under in the middles, and not uncovering this material until as late as possible up to the middle of May.

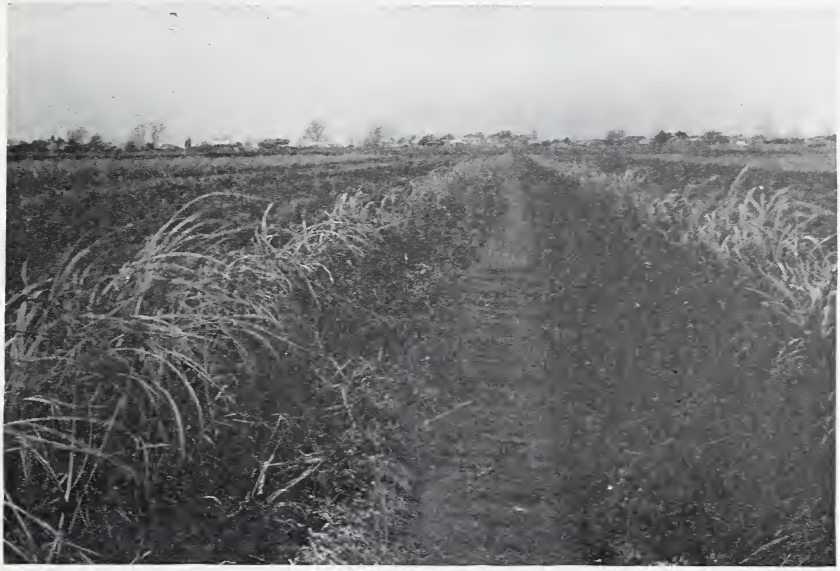

Figure 4.—Growth present in March from seed cane planted the previous summer. The young shoots have been killed by freezes, but large numbers of borers overwinter in them.

Cornstalks offer little shelter for overwintering borers in Louisiana. Corn usually is planted as soon as the danger of frost is past, and by August 15 the leaves are often too dry to invite new borer oviposition. Most of the borers remaining in the cornstalks become adults before cool weather arrives. The possibility of borers overwintering in cornstalks can be eliminated by plowing them under or burning them before winter. In the ordinary rotation system the cornstalks are plowed under in time to permit the planting of a cane crop late in September or early in October.

In Louisiana Johnson grass is the only wild grass infested by borers that is abundant throughout the sugar-producing area. As this grass is usually cut several times each season, most of the stalks are too small to furnish hibernation quarters. Borers sometimes overwinter in *Panicum dichotomiflorum* Michx., a grass not generally abundant on most plantations. Cutting and burning all large grass stalks during the winter will eliminate most of the overwintering borers in this material.

More than 80,000 borers per acre have been found overwintering in rice stubs. Plowing under these stubs before March will destroy most of these borers. Grazing with cattle, burning, flooding, or dragging and flooding rice stubble fields will materially decrease the number of hibernating borers.

CUTTING OUT AND DESTROYING BORERS IN DEAD HEARTS

Cutting out and destroying first-generation borers in dead hearts of cane shoots was a fairly common practice before the cost of labor became so high. Even at the 1950 wage level dead hearts were rogued out in some special cases, such as when only a small area on a plantation was heavily infested. Laborers go through the fields and cut out plants showing a yellow dying condition of the inner whorl of leaves, since most injury of this type is caused by borers. To obtain good control the injured cane shoot should be cut off below the borer tunnels. The borer stages should be killed as the dead hearts are cut out, or dead hearts should be sprayed with oil and thoroughly burned. The field should be cleared of dead hearts as soon as they appear in large numbers, usually late in April or early in May, and twice again at about 10-day intervals. About 90 percent of all the borers in a field may be destroyed by this method, which gives about the same control as dusting the cane with cryolite or 40-percent ryania for first-generation borers.

Since only a small percentage of the borers of later generations are destroyed, this practice is not recommended for the control of these generations. Typical dead hearts are not often caused by second-generation borers, although in jointed plants they sometimes cause dead tops.

CONTROL WITH INSECTICIDES

Extensive experiments in cooperation with the Louisiana Agricultural Experiment Station showed that dusting the cane with cryolite containing 85 to 90 percent sodium fluoaluminate or a dust containing 40 percent of ryania gave good control of either first- or second-generation borers. Dusting the first generation seldom causes a build-up of infestation by the yellow sugarcane aphid, but this aphid may increase to injurious numbers in fields where cryolite is used to control second-generation borers.

Dusting to control first-generation borers is recommended for an entire heavily infested plantation, for heavily infested areas from which many borer moths may spread to adjoining areas, and for smaller local infestations. Dusting only a small part of a large infested area is not so effective because of the possibility of reinfestation from untreated cane nearby. The cryolite or 40-percent ryania dust should be applied four times at weekly intervals, beginning with the general hatching of young borers, about April 10 to 25. The dust should be applied at the rate of about 8 pounds per acre by a ground machine (fig. 5) or about 10 pounds per acre by airplane, while the air is quiet and the plants are wet with dew, usually between 6 p. m. and 9 a. m. When the dust is applied by airplane (fig. 6) the swath width should

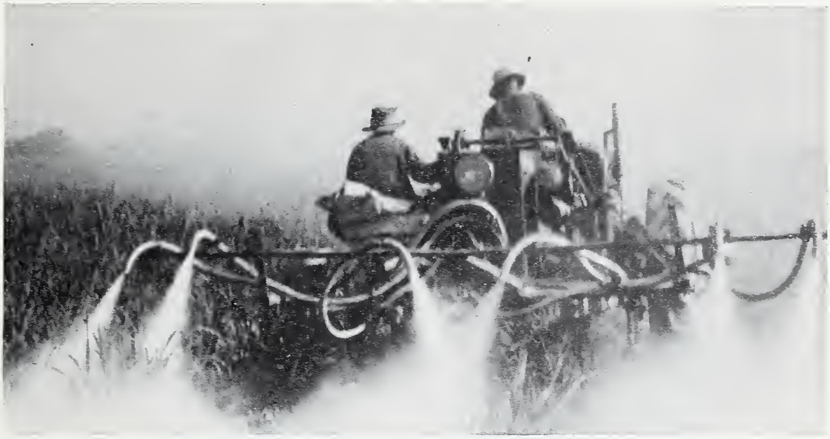

Figure 5.—Ground-machine dusting of sugarcane with cryolite to control first-generation sugarcane borers.

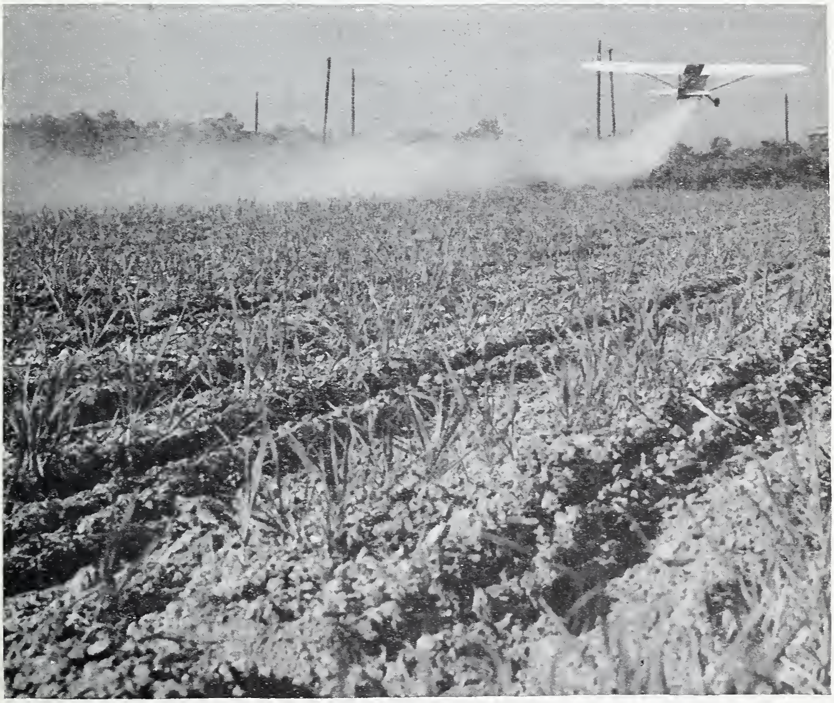

Figure 6.—Airplane dusting of sugarcane with cryolite to control first-generation sugarcane borers.

not be over 36 feet. Rotary hand guns, ground machines, and airplanes have been about equally efficient.

Dusting to control second-generation borers is recommended for fields not previously dusted, and for entire plantations or small areas where there is danger of reinfestation from adjacent untreated cane. Dust should be applied four times at weekly intervals at the rate of 10 pounds per acre, beginning with the general hatching of these borers. The dust may be applied by airplane, rotary hand gun, or a power machine built up high enough to avoid breaking the cane. Large-scale dusting must be done by airplane according to the method described for the control of first-generation borers.

In large-scale experiments conducted in 1944 and 1945, in which replicated plots of 2 to 4 acres were dusted for control of second-generation borers and compared with similar undusted plots, the average reduction in the number of borers was 51 percent and the average increase in yield of sugar 268 pounds per acre. As these were typical fields, the results are what might be expected under ordinary conditions. In small-plot tests during the period 1941–49, cryolite gave an average control of 85 percent in 30 experiments on first-generation borers and 65 percent in 22 tests on second-generation borers. Dusting for first-generation borers gives about the same return as dusting for second-generation borers except that acreage in addition to that actually dusted is protected by first-generation dusting.

Experiments with ryania for borer control were begun in 1945. In 11 small-plot experiments in which ryania was compared with cryolite for first-generation borer control, 40 percent ryania gave 80 percent control and cryolite 81 percent. In 6 small-plot experiments on second-generation borers, 40 percent ryania gave 79 percent control and cryolite 62 percent control.

None of the following insecticides have given satisfactory borer control: DDT, chlordane, parathion, heptachlor, TDE, aldrin, and dieldrin. Toxaphene and benzene hexachloride have shown some promise, but the borer infestation sometimes builds up faster following their use than after applications of either cryolite or ryania.

Insecticidal control of the sugarcane borer in southern Florida is not recommended at the present time, but this control method is being investigated in that area.

PLANTING RESISTANT VARIETIES

Varieties of sugarcane differ in their susceptibility to injury by the sugarcane borer (fig. 7). Recent investigations have shown that losses caused by the borer may be greatly diminished through the development and use of resistant varieties. In fact, the varieties now grown in Louisiana, such as C. P. 34/120, C. P. 36/105, Co. 290, C. P. 44/101, and C. P. 44/155, are not so severely injured as the old varieties, Louisiana Purple and D 74, or the P. O. J. varieties 213 and 234. Commercial varieties and varieties showing commercial promise may be rated for borer injury by determining the percentage of joints bored, and for tolerance to borer injury by determining breakage, dead tops, and deterioration resulting from known degrees of borer infestation.

Except in fields that have been swept by a hurricane, nearly all broken sugarcane stalks in Louisiana show borer injury at the point of breakage. The variety C. P. 29/320 is severely damaged by breakage following borer damage and Co. 290 is rather severely damaged in spite of its large stalk diameter. The percentages of millable stalks of commercial varieties broken following borer injury were determined for two consecutive years. When adjusted to a uniform basis of 36 percent of the joints bored, the percentages of stalks broken in the different varieties were as follows:

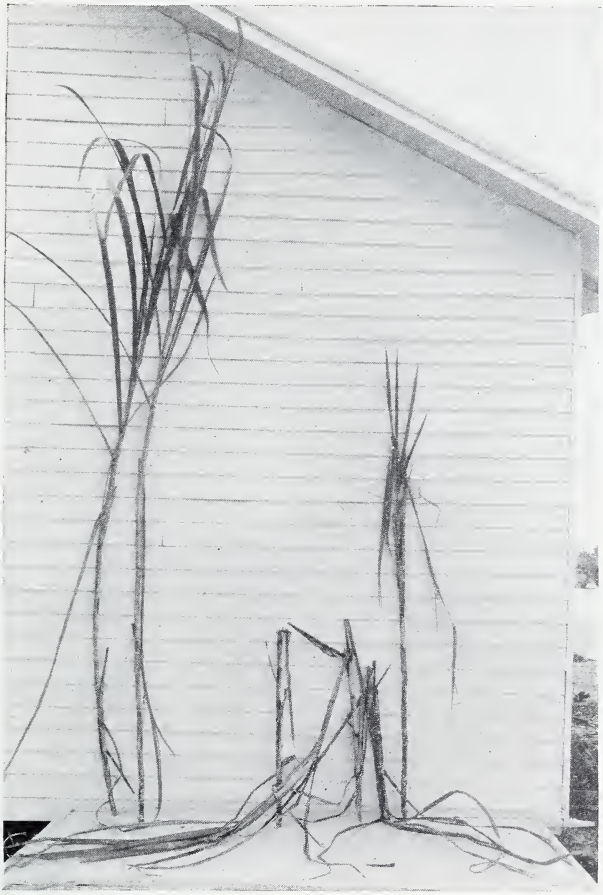

Figure 7.—Lightly infested variety of sugarcane resistant to the sugarcane borer on the left and heavily infested susceptible variety on the right.

C. P. 29/320	18
Co. 290	10
Co. 281	8
C. P. 34/120	7
C. P. 28/19	6
C. P. 33/425	6
C. P. 36/19	5
C. P. 36/13	5
C. P. 36/183	5
C. P. 29/116	4
C. P. 36/105	3
C. P. 33/243	3
C. P. 33/310	3
C. P. 29/103	2
C. P. 29/120	1

Yield data were obtained over a 5-year period in small-plot experiments in which different levels of borer infestation were secured by dusting with cryolite to decrease the infestation and with sulfur to increase it. From these data the rates of loss for each additional percent increase in joints bored could be estimated for several of the most common commercial varieties (table 1). These rates indicate the variation in losses caused in different varieties by the same degree of borer infestation but may be changed when additional data are available.

One of the main factors influencing loss from borer infestation is the susceptibility of a variety to red rot disease. Varieties have been known to become more susceptible to red rot, apparently through the appearance of a new strain of the disease, as in the case of Co. 290. If or when this occurs, the loss from a given degree of borer injury will be correspondingly greater.

Commercial varieties have been rated for susceptibility to borer damage as follows:

Susceptible:
- C. P. 29/320
- C. P. 29/103
- C. P. 33/243
- C. P. 33/310
- C. P. 33/425
- C. P. 36/13
- C. P. 36/183
- C. P. 44/101
- C. P. 44/155

Moderately susceptible:
- Co. 290

Average:
- Co. 281
- C. P. 36/105
- C. P. 29/116

Moderately resistant:
- C. P. 29/120

Resistant:
- C. P. 28/19
- C. P. 34/92
- C. P. 34/120
- C. P. 36/19

These ratings were made by the Bureau of Entomology and Plant Quarantine in cooperation with the Louisiana Agricultural Experiment Station. The variety C. P. 34/79, recently released for commercial production in Florida, has been classified as resistant. Whenever it is agronomically feasible, the more resistant varieties should be planted in areas where borer infestation is heavy. The knowledge that certain varieties do not suffer heavily from borer damage is of value in determining what plantings should be dusted with cryolite or ryania.

Table 1.—*Estimated loss in sugarcane for each 1 percent of joints bored in different varieties, based on small-plot experiments with varying levels of borer infestation*

Variety	Crop lost	Sugar lost per acre based on—		
		Actual yield in experiments	Normal yield [1]	Average yield of 20 tons of cane and 3200 pounds of sugar
	Percent	*Pounds*	*Pounds*	*Pounds*
Co. 290	1. 36	131. 9	68. 9	43. 5
C. P. 29/320	. 77	59. 7	30. 5	24. 6
C. P. 29/103	. 57	42. 2	23. 4	18. 2
C. P. 29/120	. 48	24. 5	21. 5	15. 4
C. P. 34/120	. 47	31. 7	24. 8	15. 0
Average	. 73	58. 0	33. 8	23. 3

[1] Determined from Bureau of Plant Industry, Soils, and Agricultural Engineering outfield tests on light soils.

SELECTING THE LEAST INFESTED CANE FOR SEED

It is often the practice to select the poorest cane for planting and to send the best cane to the mill. The use of bored cane for planting has often resulted in poor stands and decreased yields of cane in both the plant-cane and stubble-cane years. Many of the buds on heavily infested cane are killed directly by the borer. These buds of course fail to sprout when such cane is planted. Furthermore, bored seed cane provides optimum conditions for the development of red rot, which destroys other buds. Borer injury and disease also reduce the reserve food supply of the good eyes so that plants coming from them may not have enough vitality to reach the surface of the ground or may be unhealthy and slow growing.

For these reasons the most lightly infested cane obtainable of the variety desired should be selected for seed. When the less vigorous, more disease-susceptible varieties are planted, special effort should be made to select seed cane as free from borers as possible so that a good stand may be obtained.

In an experiment with C. P. 29/103 cane in 1942, in which weights and sucrose analyses were obtained, three 1/16-acre plots planted with cane having 56 percent of the joints bored averaged 561 pounds less sugar per acre than three similar plots planted with cane having 13 percent of the joints bored.

MISCELLANEOUS CONTROL MEASURES

An economical way of destroying all borers within cane stalks is needed to treat seed cane and cane to be shipped to uninfested areas. Soaking cane for 20 minutes in water heated to 122° F. has been found to destroy over 90 percent of all borers present, but such treatment of seed cane is not recommended for ordinary plantation use because it kills sprouted eyes and sometimes unsprouted eyes. The treatment is also rather expensive. In Louisiana, however, no unsprouted eyes have been injured by the use of the hot-water treatment late in September or early in October, when most of the cane is planted. Treatment of seed cane for 20 minutes in hot water at 126° to destroy chlorotic streak disease has been recommended by pathologists. This treatment destroys borers at the same time, which is an added advantage.

Soaking seed cane for 72 hours in water of room temperature has killed from 27 to 100 percent of the borers. The average mortality in 10 tests with this treatment was 69 percent. Soaking for 96 hours has killed from 50 to 100 percent of the borers, the average mortality being 85 percent in 7 tests. Germination of seed cane is not hindered by the 72-hour treatment; there is evidence that treated cane gives a somewhat better stand than untreated cane. This measure is of value in treating seed cane for use in isolated plantings of a few acres when water is available at little or no cost. In Florida the use of seed cane that had been soaked in a lake or other convenient natural body of water resulted in a substantial reduction in borer infestation.

Borers in the cane trash and stubs can be killed by flooding stubble fields for 3 or 4 days soon after harvest. This treatment greatly reduces the infestation the following year but is practical only where the flooding can be done at little cost. On one plantation in Florida where it is possible both to flood and to drain the fields by gravity, flooding has been practiced for several years. Since this practice was adopted, losses from borer injury have been markedly decreased with little reduction in subsequent stand of cane produced by the flooded stubble.

The use of light traps for attracting and destroying the moths has been of no economic value in borer control.

Planting trap crops of corn to attract borer moths from sugarcane fields is not recommended. Borers multiply more rapidly in corn than in cane, and few growers can determine the proper time to destroy the corn so that the borers will be killed and no moths will emerge. If the corn is not destroyed at the proper time, it becomes an added source from which nearby cane becomes infested.

SUGARCANE BEETLE

The sugarcane beetle (fig. 8) is found in all the southern States except West Virginia. It may be a serious pest of sugarcane wherever it is grown, except in southern Florida. It causes rather heavy losses of corn and rice in some localities, and also attacks cotton, strawberries, roses, and a number of wild grasses.

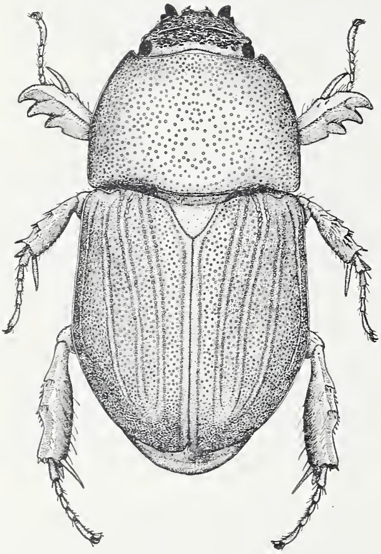

FIGURE 8.—Adult of the sugarcane beetle. Enlarged.

NATURE AND EXTENT OF INJURY

In the spring the adult beetles injure the young shoots of sugarcane by gnawing ragged holes in them just below the surface of the ground, and sometimes even before they have appeared above ground. This injury usually kills the shoot, but a sucker may sprout from below the injured portion. Severely injured fields are noticeable because of the characteristic appearance of the injured shoots, the inner leaves of which die and turn yellow. The beetles of the new generation, which begin emergence in July, feed on old cane plants and on the new growth from summer-planted cane. Although their summer and fall feeding is of some importance because it provides entrance places for red rot and other disease organisms, it is much less serious than spring injury.

The losses caused by the beetle were determined by marking the injured and noninjured plants in plant-cane fields in the spring. During the regular harvesting season the numbers of millable stalks per marked plant were recorded and samples of the injured and noninjured plants were analyzed for sucrose. The noninjured plants produced from three to seven times as much millable cane and from three to four times as much sugar as injured plants.

In years of heavy injury these beetles kill half the original plants in many fields of plant cane and reduce yields 50 to 85 percent (fig. 9). This depletion of the stand often greatly reduces the yield of the ratoon crop the following year, sometimes to the extent that it does

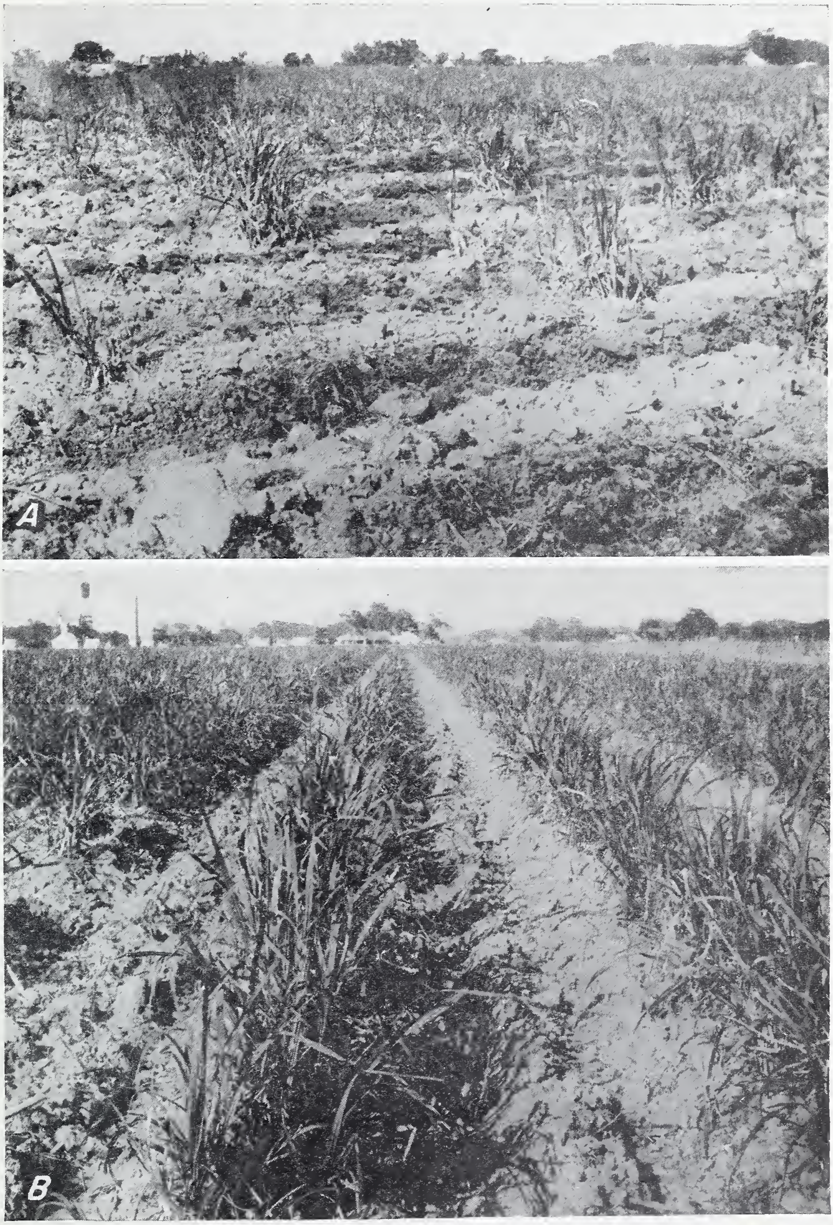

Figure 9.—*A*, Field of sugarcane showing poor stand of cane resulting from beetle injury; *B*, field with normal stand of sugarcane.

not pay to keep the stubble for a second crop. From 1930 to 1933 losses were heavy in Louisiana, those in 1933 being estimated at 25,000 tons of cane. From 1934 to 1937 losses were light. In 1938 they were heavier than for the previous years but not so heavy as for the period 1930–1933.

In addition to causing losses in the spring, beetles that emerge from July to October, inclusive, kill the growing points of summer-planted cane, gnaw buds and stalks of summer- and fall-planted cane, and gnaw into the standing canes to be harvested the same year. This decreases the stand of cane for the next year's crop. In three fields near Franklin, La., examined in September 1933, 35 percent of the millable stalks and 52 percent of the small nonmillable shoots showed injury from newly emerged beetles.

Life History in Louisiana

In Louisiana the sugarcane beetle has one generation a year. It overwinters in the adult stage, mainly in the sod areas in which it breeds. Soil samples have shown them overwintering in large numbers on knolls in sod pasture; others hibernate in sugarcane fields. The numbers overwintering in the different locations vary somewhat in proportion to the numbers breeding in these locations, although beetles have been found overwintering in locations where there were no larvae.

The overwintered adults begin feeding during the first warm days in February or March and continue feeding until about June 30. Egg laying begins shortly after the adults begin to feed, but most of the eggs are laid near the end of the feeding period, when many of the adults fly to sod areas for that purpose.

The larvae are white, fleshy grubs about 1¼ inches long when full-grown, with bodies that are curled into a semicircle. They are most abundant in pasture-sod areas where over 100,000 have been found per acre. Other breeding areas, in the order of their importance, are plantation roadways, stubble-cane fields, plant-cane fields, and corn-soybean fields. No larvae were found in woodlands.

The grubs pupate in small elliptical cells which they form near the surface of the soil, and change into adult beetles during the summer. The new crop of beetles emerges from the ground during the period July to August, inclusive.

Natural Control

Wet periods and flooding help to control beetles, as larvae and pupae are killed in water-soaked soil. Skunks eat large numbers of adults and apparently are of much value in some locations. Several species of birds feed on the adults, but apparently are ineffective because the beetles hide underground during the day. The larvae of a flesh fly, *Sarcophaga rapax* Walk., have been observed feeding on the adults. This species often breeds in dead insects, however, and its status as a parasite of the sugarcane beetle is doubtful. A tachinid fly, *Microphthalma disjuncta* (Wied.), which parasitizes the larvae, is of minor value.

In 1934 a total of 530 females and 9 males of a parasitic wasp, *Campsomeris dorsata* (F.), were introduced from Puerto Rico and released near Franklin, La., but no recovery has been made. One hundred giant toads were introduced into Louisiana in 1936 from Puerto Rico, where they are an important enemy of related insects, but this toad apparently was unable to survive in Louisiana.

CONTROL MEASURES

Dusts, sprays, and baits containing insecticides have been applied to infested sugarcane in attempts to control the adult beetle in the spring. None of these treatments have given good results. Recently developed insecticides have not been tested against the adult beetle and may prove of value.

Hand picking of beetles from the soil around injured plants has been tried, but no decrease in injured plants has been noted.

In the spring and fall large numbers of sugarcane beetles emerge at night, and they are strongly attracted to lights ranging in wattage from 200 to 500 on warm, still nights between dusk and about 9 p. m. During the spring of 1934 more than 75,000 beetles were collected on one plantation at fifteen 500-watt lights. Good catches are made only when the temperature has been over 80° F. during the day and over 75° at 7 p. m., when the air is fairly calm and the ground is dry. Beetles approach to within about 12 feet of a light but seldom go nearer than 1 foot. Small numbers are attracted to automobile and lantern lights. Females have been somewhat more abundant than males in collections made at lights. Carrot beetles have also been collected at lights. The injury of these beetles to sugarcane is similar to that of the sugarcane beetles.

Many more beetles are collected at clear lights than at red or blue lights of the same wattage. Fewer plants are injured in fields where the beetles have been collected at lights than in fields where no collections have been made. Injury in fields containing light traps was less after trapping was begun. As eggs are laid mainly at the end of the feeding period and females collected at light traps usually contain eggs, trapping with lights should be of some value in decreasing the abundance of the next generation.

Experiments and observations indicate that variations in the time when the soil is plowed back against the cane rows do not affect beetle injury.

Burning the trash left in harvesting had no apparent effect on the amount of beetle injury.

The growing of sweetclover on sugarcane rows has not been found to decrease beetle injury, but when this plant is grown on ditches and the edges of roadways, fewer beetle larvae develop there.

Injury from the sugarcane beetle can be reduced by the elimination of its breeding areas. This is accomplished in sod pastures, on roadways, and on headlands by plowing or by planting some non-sod-forming plant such as one of the clovers. Flooding is also successful, but it is seldom practicable to flood breeding areas. Bermuda and other sod-forming grasses in sugarcane fields should be destroyed.

Beetles have shown no preference for any particular varieties of cane, but the heaviest loss of stand usually occurs among the varieties producing the fewest plants per acre at the time of beetle injury. Some varieties produce so many plants that many can be lost without materially affecting the crop. Varieties also differ widely in their ability to survive beetle injury, the most vigorous ones being best able to recover from it. Liming acid soils increases the number and vigor of the cane stalks.

Planting early in August usually gives a better stand of cane, and consequently less beetle injury, than planting late in September or early in October.

GRAY SUGARCANE MEALYBUG

The gray sugarcane mealybug (fig. 10) is found throughout southern Florida and Louisiana and on some farms in the northern parts of these States, as well as in Georgia, Alabama, and Texas. It is not known to occur in Mississippi.

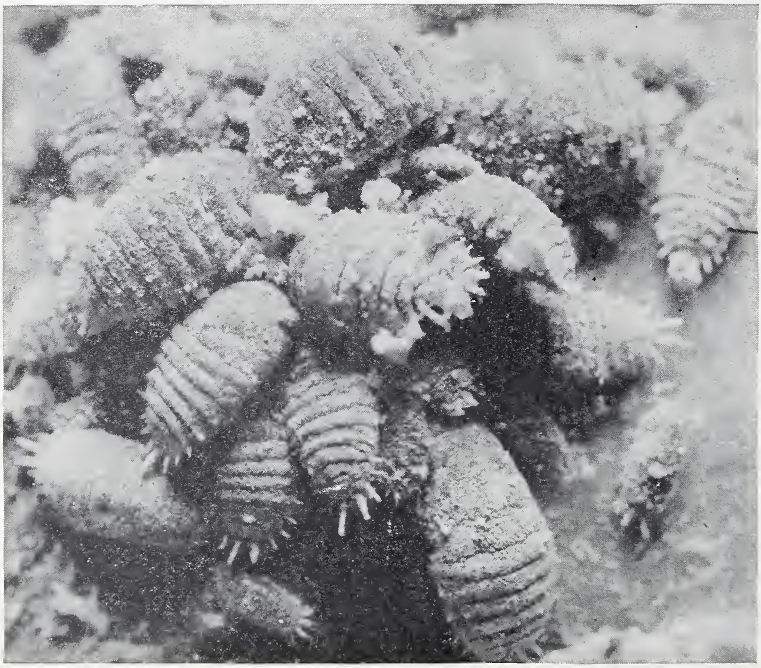

Figure 10.—Sugarcane mealybugs. Enlarged.

The female mealybug, which is more commonly seen than the male, is a soft-bodied, grayish insect about ⅛ inch long when full-grown and of a flattened-oval shape. It surrounds its body with a white webby, mealy substance in which the eggs are deposited. Mealybugs most often feed on the cane plant between the sheath and the stalk and suck the juice from the sugarcane. Although usually considered a minor pest, the mealybug does cause some direct loss through its feeding. Its presence also makes sirup manufacture more troublesome and generally lowers the quality of the sirup.

The mealybug parasite *Pseudaphycus* n. sp. is now well distributed over the areas infested by the mealybug in continental United States and is an important factor in keeping it under control.

The following instructions help to control the mealybug or prevent its spread to uninfested fields where sugarcane is grown for sirup:

(1) Plant only clean (uninfested) seed cane.

(2) Plant the uninfested cane at some distance from fields where the mealybug occurs.

(3) Cut cane close to the ground so that the mealybugs will have less cane on which to feed during the winter.

(4) Destroy all scraps of cane left on the fields and around the mills after grinding.

(5) Avoid carrying the mealybug from place to place. Brush out trucks or wagons after they have been used in hauling infested cane to the mill. Live specimens should not be carried about for exhibition or for any other purpose.

Soaking seed cane for 30 minutes in water held at 122°–126° F. has been used successfully to eradicate the mealybug from infested areas. Soaking seed cane in water of ordinary temperature for 7 days has also been satisfactory.

SUGARCANE WEEVIL

The sugarcane weevil has been found only in Louisiana. This weevil is dark brown and about ⅜ inch long and ⅛ inch wide. The larva is a white, legless grub with an amber-colored head and is about ⅕ inch long when full-grown. The pupa is white until shortly before emergence, when it develops a brownish tint. All stages of the weevil are found in sugarcane fields at almost any time of the year (fig. 11).

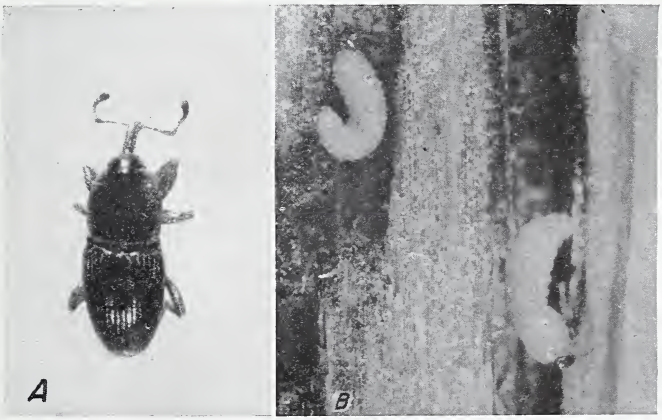

FIGURE 11.—Sugarcane weevil: *A*, Adult; *B*, sugarcane stubble showing weevil injury and larvae. Enlarged.

The adults are most numerous in August and September and the larvae during the winter months.

The larva tunnels below and just above the surface of the ground in seed cane, young plants, and stubs. The tunnels resemble those made by the sugarcane borer except that they are much smaller. They are most often found at the nodes and near the outer surface of the stalk. In some cases the stubble is riddled with tunnels and all eyes are killed either directly by the weevil larva or by the entrance of disease organisms into the tunnels. Cane eyes are often hollowed out by the weevil larva to form a pupal chamber. As a rule the injury is much heavier in second-year than in first-year stubble cane. Plantcane is not often infested, but when it is the larvae bore into the young plants near the point where they join the seed piece.

Although weevil injury varies with the locality and the year, it is sometimes an important factor in reducing the stand of stubble cane. Fields have been examined in which over half of all the cane eyes had been killed by weevil larvae; also, as many as 5 percent of summer-planted cane shoots have shown weevil injury in January. Weevil injury is usually greater in well-drained than in poorly drained soils, and in light than in heavy soils. Injury is greatest in the light, well-drained soils in the western part of the Louisiana sugar section.

The only effective control measure known is to plant vigorous varieties that will give a good stand of stubble cane in spite of weevil injury. Since red rot often attacks the stubble through such injury, varieties that are resistant to red rot should be planted where agronomically practical in areas subject to injury by the sugarcane weevil. No stage of the weevil has been found to survive the soaking of seed cane in water held at 122° F. for 30 minutes.

WIREWORMS

Wireworms are yellowish, slender, smooth, wiry worms a half-inch to an inch or more long, which bore into buds of planted cane and stubble and into young plants below the surface of the ground. They are the young of click beetles, and seriously deplete the stand of sugarcane in some areas. Injury is greatest in the winter months when the cane is growing very little, if any. In one area bordering the Mississippi River in Louisiana, wireworms so reduce the stand of cane planted at the usual time in the fall that the crop is almost worthless. The wireworms gnaw out the eyes on the stalks of fall-planted seed cane during the fall and winter months before growth starts. Wireworms causing injury in that area were determined as *Melanotus* sp., *Conodorus* sp., and probably *Aeolus* sp.

Losses from the wireworm in southern Florida (fig. 12) have been heavy at times but have varied widely from year to year. A sugar company estimated that in 1934 losses on 300 acres at Canal Point amounted to 5 tons per acre. In 1935 the loss was estimated at 4 percent on 13,500 acres in the Everglades. In some fields it was 50 percent, and one 60-acre field was abandoned because of loss of stand caused by wireworms. Fairly heavy losses have continued during recent years. In 1949 a field was observed at Okeelanta in which 95 percent of the initial stand had been destroyed by wireworms. Losses of new seedling varieties have also resulted from wireworm injury at the experiment stations at Canal Point and Belle Glade, where the only sugarcane breeding work in the continental United States is conducted. In some fields in the Fellsmere area it is difficult to get a stand on account of wireworm damage. Chemical treatment of soil in that area in wireworm-control experiments in 1950 gave increases in yield of as high as 36 percent.

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CORRECTION

United States Department of Agriculture
Circular No. 878. Pests of Sugarcane and Their Control

On page 24 the seventh sentence in the last paragraph should read--

> "Losses of new seedling varieties have also resulted from wireworm injury at the experiment stations at Canal Point, Belle Glade, and Clewiston, where most of the sugarcane breeding work in the continental United States is conducted."

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JAN 5 - 1952
U.S. DEPARTMENT OF AGRICULTURE

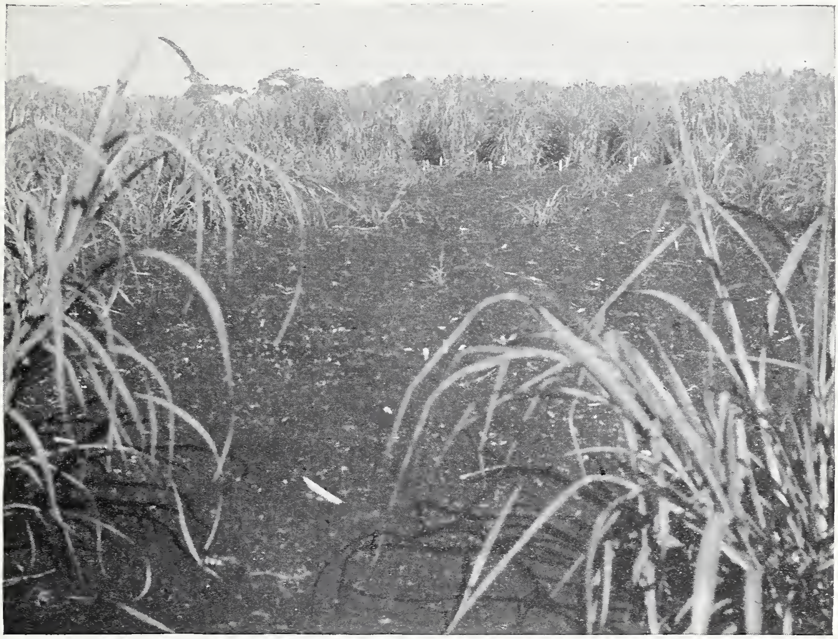

FIGURE 12.—Wireworm injury to sugarcane in southern Florida. Note almost complete loss of stand.

The most abundant wireworm injuring sugarcane in the Everglades was determined doubtfully as *Melanotus communis* (Gyll.). It was probably this species, however, because large numbers of adults definitely determined as *M. communis* were observed in cane fields. Other wireworms found in sugarcane fields in Florida were *Conoderes amplicollis* (Gyll.) (=*Heteroderes laurentii* (Guer.)) and *Orthostethus infuscatus* (Germ.).

CONTROL

To find means of overcoming losses from wireworms in Louisiana, an experiment was begun in 1941 in which summer planting was compared with fall planting. Four replications of each of four varieties were planted between August 1 and 15, and four replications of the same varieties were planted between September 20 and October 10. Each plot was three rows wide and 50 feet long. The planting was at the rate of two running stalks of seed cane per row in all cases. The stand of cane was increased greatly by summer planting and for C. P. 29/320, a variety frequently planted in the area, over six times as many plants were obtained.

In 1944 summer and fall plantings were compared in three experiments, two in light soil and one in a mixed type of soil, with two varieties of cane in each experiment. Plantings were made between August 1 and 10, and again on September 20. Plantings of each variety were replicated two or more times for each date of planting in each experiment. Each plot was three rows wide and extended the entire length of the field. On March 23, 1945, counts were made of the plants in six to nine 25-foot lengths of row in each plot. In both varieties in each experiment more than six times as many plants per acre came up in the summer-planted as in the fall-planted plots. Wireworm injury was so heavy in all experimental areas that the stand of fall-planted cane was far below normal.

Results of these experiments showed that in areas subject to heavy wireworm injury cane may be planted as early in August as agronomically practical. Although summer planting may increase borer injury in the plant-cane crop, the reduction in losses caused by wireworms should be many times greater than any increase in losses caused by the borer.

In experiments conducted during 1947–50 several new insecticides have given excellent control of wireworms. On the basis of these experiments, it is recommended that 200 pounds of 1-percent chlordane or 400 pounds of 1-percent toxaphene per acre be applied on the cane in the planting furrow with a fertilizer distributor to control wireworms where summer planting is not done.

In Florida a number of experiments were conducted on the control of wireworms by flooding for different periods of time during April, August, and September, but it was apparent that flooding for as long as 2 weeks is of little, if any, value in controlling wireworms in the Everglades. Results of examinations of samples from fertilizer plots receiving 300 pounds of kainite per acre and from untreated check plots indicated that this amount of kainite did not decrease wireworm abundance under Everglades conditions. Observations indicate that earlier planting to establish a good stand of plant cane before winter helps to combat wireworm injury in Florida as well as in Louisiana. Several new insecticides have given good wireworm control in experiments under Florida conditions.

WEST INDIAN SUGARCANE FULGORID

The West Indian sugarcane fulgorid occurs throughout southern Florida and in parts of Louisiana, Mississippi, Georgia, and northern Florida. The adult fulgorid is about ⅕ inch long, pale green with transparent wings, and often bears white cottony fluff at the rear end of its body. The translucent white, elongate-oval eggs, about $\frac{1}{25}$ inch long, are laid several in a row side by side in a slit on the underside of the leaves. The slit is covered with a little white cottony fluff. The nymph, or immature insect, is pale green and bears a characteristic long, taillike white filament at its rear end. Both nymphs and adults are nearly always found on the underside of the leaves. They are sometimes present in the central whorl but rarely on the upper leaf surface. They have been found on several other grasses besides sugarcane.

This fulgorid causes direct injury by sucking juice from the cane leaves. Its egg-deposition slits also form entrance places for red rot disease, its droppings of honeydew form a medium for the development of sooty mold on the leaves, and it may possibly be a carrier of sugarcane mosaic or chlorotic streak disease. It is one of the most common pests of sugarcane in the West Indies, where it was formerly called black blight because of the sooty mold associated with it.

In the continental United States injury by this insect is usually of minor importance, but in September 1936, at Fellsmere, Fla., fields of Co. 290 cane were damaged more by this insect than by any other. The leaves were black with sooty mold growing in the honeydew from the fulgorids, and many of the heavily infested leaves withered and died. It was estimated that at least 10 percent of the crop would be lost. Although other fairly heavy infestations have been observed in both the Fellsmere and the Lake Okeechobee areas in Florida, the injury caused by this insect is usually light or negligible. In Georgia, Mississippi, or Louisiana, no appreciable injury has been observed.

A small wasplike parasite, *Gonatopus* sp., the larva of which forms a prominent seedlike sac on the side of the fulgorid's abdomen, usually keeps this pest under control. No measures for the control of the fulgorid have been developed, but insecticides, such as nicotine, parathion, or benzene hexachloride, that control the aphid should control this insect.

WEST INDIAN SUGARCANE MITE

The West Indian sugarcane mite was first found in continental United States in 1935 on experimental plantings near Houma, La. That particular infestation was eradicated, but the mite was later discovered near Canal Point, Fla., where the only known infestation in the country now occurs.

The nymphs of the mite are colorless or very pale brown, scarcely visible to the naked eye. They are most often found between the leaf sheath and the cane stalk on the more tender upper parts of the plant. The older stages are found embedded in the stalk rind, cane bud, and leaf sheath, where they form blisterlike exudations on the surface (fig. 13). The blisters are about $\frac{1}{50}$ to $\frac{1}{15}$ inch in diameter, light amber in color, darkening to reddish brown with age. There is usually a craterlike depression in the center of each blister. The presence of the mite is detected by these blisters.

Damage caused by this mite apparently varies considerably with local conditions and varieties of cane. There is some direct loss and also an indirect loss from red rot and other disease organisms entering mite lesions on the stalks and leaf sheaths. The mite has a marked preference for varieties having barrels of large diameter. According to reports, losses from this mite are heavy in some foreign countries but of little consequence in others. Although the mite is of minor importance, its spread should be restricted by not moving sugarcane from the infested area unless it has been soaked for 30 minutes in water held at a temperature of 122° F.

LESSER CORNSTALK BORER

The lesser cornstalk borer (fig. 14) is found throughout the sugarcane-growing area of continental United States. The larva is a slender, greenish worm about an inch long when full-grown, with dark brown longitudinal bands, and makes a rapid jerking motion when disturbed. The larva bores into the young cane plant at or below the surface of the ground and then usually upward, killing the young cane shoot. Its injury resembles that of the sugarcane borer, except that the hole made by the lesser cornstalk borer is close to the soil surface and has a tubular burrow extending outward from it. The burrow consists of soil particles which the borer webs together with silk. The larva pupates in this burrow and changes into a small moth.

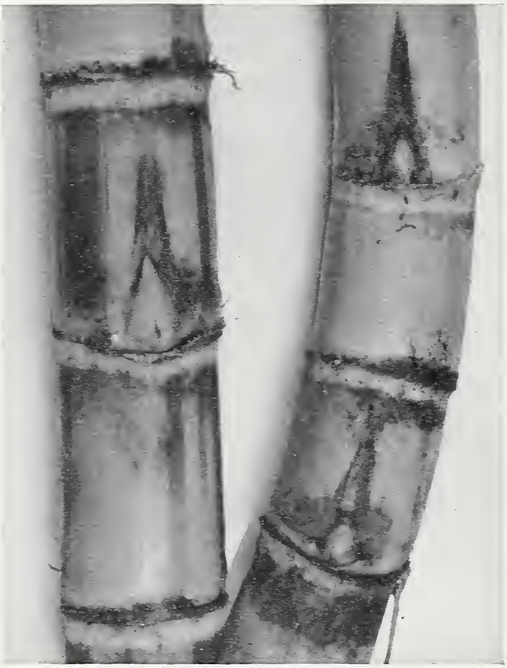

FIGURE 13.—Stalks of sugarcane injured by the West Indian sugarcane mite. Note damage about the nodes and in the bud grooves.

Injury from the lesser cornstalk borer is found from March to June. The infested plants usually put out suckers from below the injury, and for this reason there is little loss of stand but only delayed growth with somewhat lower sucrose content at harvesttime. Greatest injury from this insect has been observed in southern Florida, where as many as 30 percent of the plants were infested in some fields. Infestations were lighter in fields where the trash had not been burned than in fields where it had been. Nonburning of trash may therefore be of value in areas where there is heavy injury from the lesser cornstalk borer, except in Louisiana where burning of trash is advisable to destroy overwintering sugarcane borers.

FALL ARMYWORM

The fall armyworm (fig. 15) is found throughout the cane-growing areas of continental United States. The larva is grayish with three whitish longitudinal bands and a blackish head. It is about 1⅝ inches long when full-grown.

This armyworm sometimes appears on small cane in the spring and on newly planted cane in the late summer or early fall. It may eat most of the foliage on the young shoots. Usually only one generation attacks the plants in injurious numbers, and often by the time injury is noticed most of the larvae have reached full growth. It is then too late to apply control measures.

Most insecticides have given unsatisfactory control, but in a test in 1946 a 10-percent DDT dust applied at the rate of about 10 pounds per acre reduced the fall armyworm population by 91 percent, and a 5-percent DDT dust, applied at the same rate, reduced the population by 83 percent in 2 days. In 1948 a 20-percent toxaphene dust applied at the rate of 10 pounds per acre gave 92 percent control after 6 days in one experiment and 93 percent control in another. Ten percent DDT gave 82 percent control. During the plowing of infested fields, birds devour a considerable number of worms.

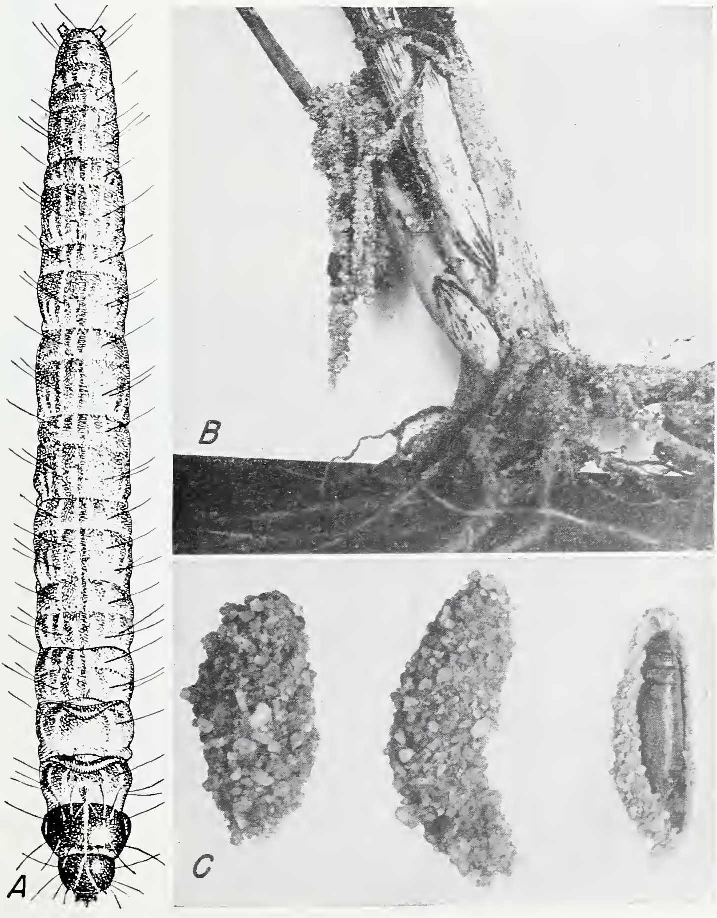

FIGURE 14.—The lesser cornstalk borer: *A*, Larva greatly enlarged; *B*, feeding tubes attached at entrance of tunnels, at base of a sorghum stalk; *C*, cocoons.

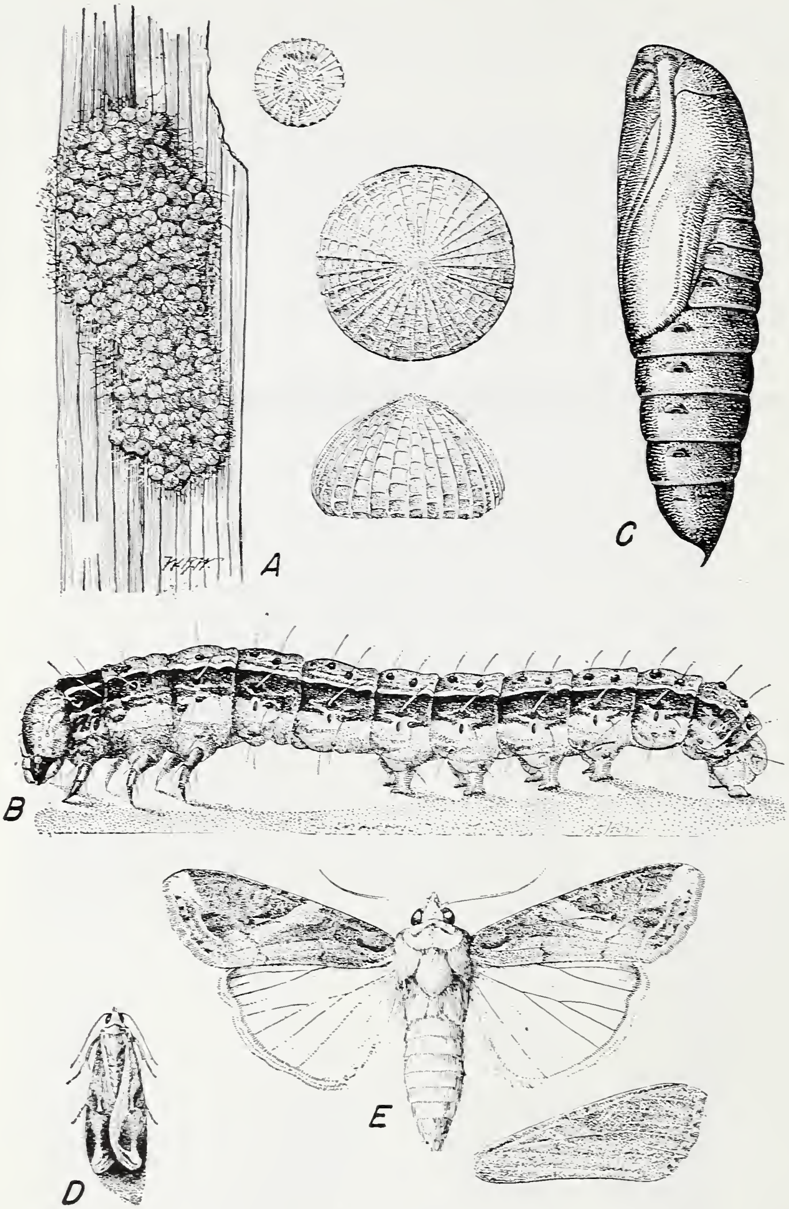

FIGURE 15.—The fall armyworm: *A*, Eggs; *B*, larva; *C*, pupa; *D*, moth in resting position; *E*, male moth and right front wing of female moth. Enlarged.

SMALL SOIL ANIMALS THAT ATTACK SUGARCANE ROOTS

Small soil animals, such as centipedes, millipedes, springtails, bristletails, and earwigs, cause damage to sugarcane in two ways. Primarily they cut off or gnaw into cane roots or prune off the root hairs, thereby directly damaging the root system and checking plant growth. This type of injury is especially noticeable in newly planted cane. All new roots are sometimes cut back by these soil animals. Secondarily the wounds they cause permit easy entrance of and injury by root-rotting organisms. This type of injury is serious in heavy soils where root-rot is prevalent. The average numbers of the most important injurious soil animals found in extensive surveys in Louisiana and in limited surveys in Florida and Georgia are tabulated below (1 square-foot soil sample 8 inches deep):

	Louisiana	*Florida*	*Georgia*
Centipede (*Hanseniella unguiculata* (Hansen))	80	143	94
Springtails:			
Pseudosinella violenta (Folsom)	22	31	23
Lepidocyrtus cyaneus Tullberg	3	Rare	0
Onychiurus armatus (Tullberg)	35	80	66
Bristletail (*Iapyx* sp.)	30	0	3
Snail (*Zonitoides arboreus* (Say))	19	Rare	0
Centipede (*Arenophilus bipuncticeps* Wood)	3	7	4
Injurious millipedes	10	Rare	0
Total	202	261	190

The centipede *Hanseniella unguiculata* (fig. 16, *A*) is the most abundant of the injurious soil animals found in sugarcane fields. It is white and when full-grown measures 3 to 4 mm. long and 0.3 to 0.5 mm. wide. Its feeding scars usually take the form of pits and ragged, irregular cavities in the roots. Root tips are also gnawed off.

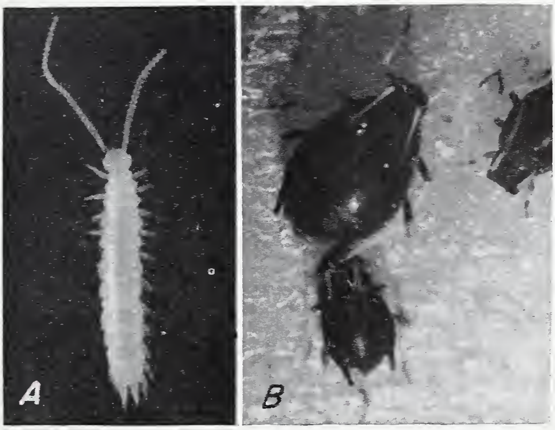

Figure 16.—*A*, The centipede *Hanseniella unguiculata* (Hansen); *B*, adults of the rusty plum aphid. Enlarged.

The springtail *Onychiurus armatus* is white, segmented, and has only a rudimentary springing apparatus. It is about 1 mm. long and about 0.2 mm. wide.

Another springtail, *Pseudosinella violenta*, is white and very active. It has a well-developed appendage by means of which it can make quick leaps. It gnaws into roots, especially into the growing root tips, or into the portions immediately behind the tips, cutting them almost entirely off. It has also been observed feeding upon root hairs. It is slightly broader and shorter than *Onychiurus armatus*. *Lepidocyrtus cyaneus* is a blue springtail similar in size and habits to *P. violenta*.

The bristletail *Iapyx* sp. is 3 to 4 mm. long and 0.2 mm. wide. The snail *Zonitoides arboreus* is small and round, its shell measuring about 1.5 to 2 mm. in diameter by 0.5 mm. in thickness. It gnaws small round pits in the roots. It is abundant in some fields but not so generally distributed as most of the other injurious soil animals.

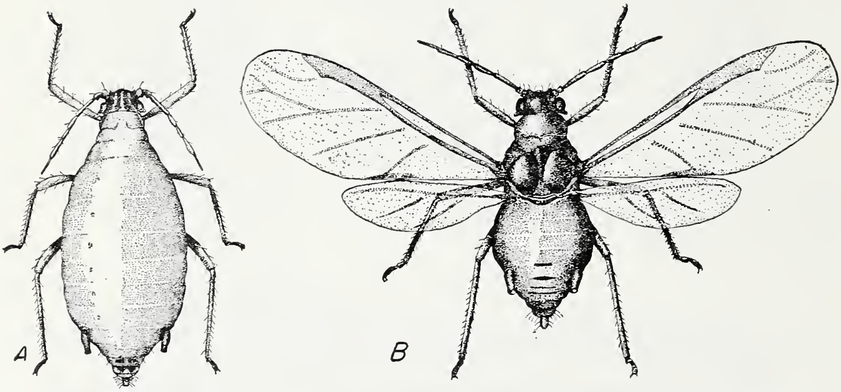

Figure 17.—Corn leaf aphid: *A*, Wingless form; *B*, winged form. Enlarged.

Other small soil animals injuring sugarcane roots are a large centipede, *Arenophilus bipuncticeps*, a flat gray millipede, a round brown millipede, and an earwig.

There are several promising methods of decreasing injury by soil animals. Summer planting of sugarcane, which allows the cane to develop a good root system before the next growing season, lessens the injury by soil animals to plantcane. In heavy black lands in Louisiana improved drainage materially reduces the numbers of soil animals. Rotation with dry-land crops offers little possibility of decreasing the numbers of soil animals, but rotation with rice, which involves the necessary flooding of fields, kills practically all soil animals. A plant-cane field following rice has about one-fourth as many injurious soil animals as one following corn and soybeans, but after a year of a dry-land crop following rice the soil fauna reach normal again.

Several of the new chemicals have been applied on the seed cane in the planting furrow. Applications of 1-percent toxaphene or 1-percent chlordane at 400 pounds per acre on heavy soils gave good reductions in soil animals and increases in yield.

INSECTS THAT TRANSFER SUGARCANE DISEASES

In Louisiana four species of plant lice carry sugarcane mosaic disease from infected to uninfected plants. They are the rusty plum aphid (fig. 16,*B*), the corn leaf aphid (fig. 17), the greenbug, and the sedge aphid. The sharp-nosed grain leafhopper (fig. 18) is also suspected of carrying mosaic. Although the sedge aphid has not been observed on sugarcane in Louisiana or elsewhere in continental United States, it does occur on a sedge that grows in sugarcane fields, and undoubtedly moves to sugarcane plants from this host. Observations on a great number of plants have shown that the rusty plum aphid was about 14 times as abundant as the corn leaf aphid on sugarcane and about 25 times as abundant as the greenbug. The greenbug has not been observed on sugarcane in other sugarcane-producing States. The rusty plum aphid and the corn leaf aphid have seldom been found on sugarcane in other States than Louisiana, except for moderate numbers of the rusty plum aphid observed in a sugarcane-growing area near Fellsmere, Fla.

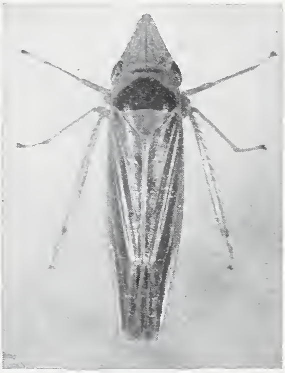
Figure 18.—Adult of a sharp-nosed grain leafhopper. Enlarged.

The corn leaf aphid is normally present on sugarcane only in the winter and early spring, and then only in the central whorl of leaves. It is seldom found on this plant later in the season when the wild grasses growing in and around sugarcane fields are available. Among the grasses it prefers Johnson grass, maidencane, jungle-rice, and crabgrass, in about the order named.

Preliminary results indicate that the corn leaf aphid is the most efficient insect carrier of mosaic, owing to its habit of feeding mostly in the tender and disease-susceptible leaves of the central whorl of its host plant. After the new growth of its favorite grasses appears in the spring, the aphids move to it. If the grasses are susceptible to mosaic, the aphids may transfer the disease from mosaic-infected cane to them. Later the mosaic-infected grasses are killed by plowing or hoeing, or become mature and unattractive to the aphids. The aphids may then leave the grasses and move to uninfested sugarcane, taking the mosaic disease with them. It seems likely that most of the mosaic transfers by the corn leaf aphid are accomplished in this manner.

The rusty plum aphid is the least efficient of the three species of aphids that seem to be chiefly responsible for transferring mosaic to cane, but its greater numbers, especially on variety Co. 290, probably make it the most important species in many fields. Mosaic spread by this aphid is thought to be mainly from cane to cane although there is undoubtedly some transfer from wild grasses to cane. The aphid feeds mainly on the collar lobe where the leaf blade joins the sheath, both on sugarcane and on most of the larger grasses, although it is sometimes found in the central whorl. On the smaller grasses, such as yellow bristlegrass and goosegrass, it has been observed in all positions along the stems and even on the glumes. The rusty plum aphid is around sugarcane fields all winter on broomsedge and bushy beardgrass growing in and alongside ditches. When the cane comes up the aphids move to or are carried by ants to sugarcane plants. These aphids are usually attended by ants that often form a protective dirt or borer-frass covering around them. They have also been found feeding on plum twigs in the sugarcane section, but plum trees are comparatively rare around sugarcane fields.

The rusty plum aphid has shown a consistent preference for the variety Co. 290 over Co. 281. The larger collar lobe borne by Co. 290 affords the aphid a greater feeding area and more protection from rains than that of Co. 281. No varietal preference has been observed among other known and possible mosaic carriers.

The greenbug, or spring grain aphid, has not been reported as feeding on sugarcane elsewhere than in Louisiana and not until recently in that State. It is more abundant during the spring and early summer, often feeding in the central whorl of leaves, where in the past it has probably been mistaken for the corn leaf aphid. It also feeds on other parts of the plant, including the underside of the leaf tips. This aphid matches the color of green sugarcane more closely than any other aphid found on that plant, thus making it the most difficult to find.

As a carrier of mosaic the greenbug is apparently more efficient than the rusty plum aphid but less so than the corn leaf aphid. It carries the disease both from cane to cane and from grass to cane. Since crabgrass is one of its favorite host plants, its transfer of mosaic from this grass to cane is probably of much importance. It is more unevenly distributed in the Louisiana sugar section than the rusty plum aphid or corn leaf aphid, but is especially abundant in the lower Mississippi River area and apparently is responsible for much of the disease spread there. In many fields it is as abundant as the corn leaf aphid, but generally it is less numerous.

The sharp-nosed grain leafhopper (fig. 18) is usually more abundant than the total of all other sucking insects on sugarcane, excluding mealybugs. Both adults and nymphs feed almost entirely in the central whorl of leaves. This leafhopper is present on sugarcane throughout the winter whenever there are any live plants. Limited trials have shown that this insect does not transfer mosaic. It has, however, been found to transfer chlorotic streak disease of sugarcane. During the years 1943–46 it averaged 80 times as numerous on variety Co. 281 as the corn leaf aphid and 17 times as numerous as all known mosaic carriers combined. Further studies are needed to determine whether or not it may be equal to or greater in importance than any of the known mosaic carriers.

The abundance of the different mosaic carriers does not appear to be affected by soil type. In Louisiana, however, the aphids and leafhoppers have been more numerous on the better-drained lands near the front of the plantations, where there are usually more host grasses and more ants, than in the back lands.

The rate of mosaic spread in a given field depends on the number and species of the various carrier insects present, the species and abundance of alternate hosts of both the insects and the disease, the strain or strains of mosaic present, and the susceptibility of the sugarcane as governed by the variety, rapidity of growth, and age.

Crabgrass is thought to be the most important wild host of sugarcane mosaic. It is the most abundant of the grasses found in sugarcane fields during the period of heavy mosaic spread. It is also a host plant for the three important species of known carrier insects and is highly susceptible to mosaic. As high as 37 percent of the stools of crabgrass have been found infected in fields of Co. 281 that were nearly mosaic free at time of planting. Although other factors often overbalance the importance of crabgrass in mosaic spread, it seems that the elimination of as much as possible of this and the other mosaic-susceptible grasses from sugarcane fields would be helpful in reducing the spread of the disease.

Corn is susceptible to mosaic and is a host of several of the insects that carry mosaic. Experiments to date, however, indicate that the presence of growing corn does not materially increase mosaic spread in adjoining sugarcane.

The best method of preventing mosaic infection in seed plots is to locate them in areas where there are few plant hosts of mosaic and a scarcity of carrier insects. The best locations are usually in the back of the plantations and surrounded or nearly surrounded by woods.

OTHER INSECTS ATTACKING SUGARCANE

The yellow sugarcane aphid (fig. 19, *A*) is distributed throughout the sugarcane-growing area of continental United States. It is found principally on the underside of the leaves, where at times it becomes so numerous that the leaves turn yellow or red and die. The injury is usually most severe on broad-leaved varieties. This aphid is not known to transfer mosaic disease.

The dusting of sugarcane with cryolite in midsummer to control second-generation borers is often followed by a heavy increase in infestation of the yellow sugarcane aphid. Cryolite kills the predators

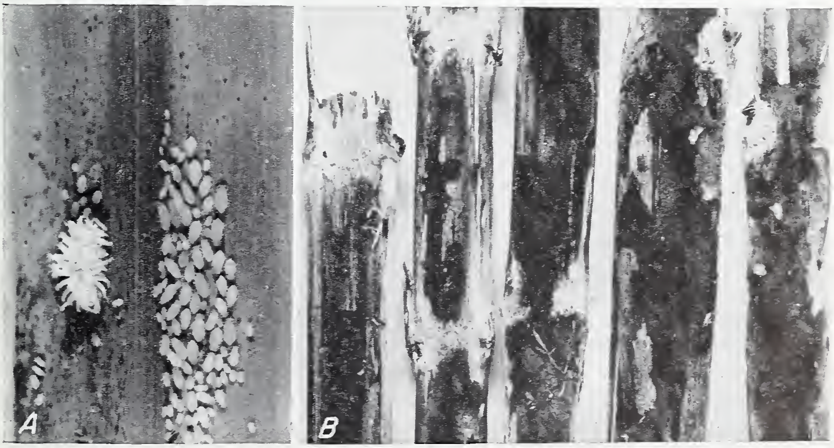

FIGURE 19.—*A*, Colony of yellow sugarcane aphids on underside of sugarcane leaf (cottony mass at left is a ladybeetle larva feeding on the aphids); *B*, termite injury to sugarcane. Enlarged.

and the aphid is thus able to multiply unhindered since it has no internal parasites, as have all other aphids feeding on sugarcane. Although spring dusting with cryolite to control first-generation borers may cause a larger aphid population, apparently such an increase at that time has little effect on the final yield of sugarcane. However, in some fields and in some years the aphids have been so heavy after second-generation dusting that their damage may have partly offset the benefit of borer control. This aphid can be controlled with nicotine, but the high concentration required to kill it makes control by this means impractical. Some of the new insecticides showing promise for control of the borer are also effective against the sugarcane aphid.

Termites have been found attacking sugarcane in newly cleared woodland areas. They eat out the inside of the stalks in much the same manner as they attack wood (fig. 19, *B*). Removing all pieces of wood from recently cleared areas reduces the danger of injury by termites.

The black cutworm, the granulate cutworm, the fall armyworm, the armyworm *Leucania latiuscula* Herr.-Schaef., and the cutworms *Elaphira chalcedonia* (Hbn.), *E. nucicolora* (Guen.), and *Agrotis malefida* Guen., have all attacked sugarcane in Florida at one time or another. *Leucania latiuscula* has occasionally caused heavy injury, as in 1932 when areas as large as 120 acres of young stubble and plant cane were eaten to the ground by this insect. In 1936 it again did almost as much damage. Controls discussed under the fall armyworm also apply to the other related species.

White grubs, the larvae of May beetles, sometimes cause serious damage to sugarcane planted in the sandy soil near Lake Okeechobee in Florida. They feed on the roots of the plants. The species common there are *Phyllophaga latifrons* (Lec.), *P. clypeata* (Horn), and *Cyclocephala immaculata* (Oliv.). They are thick white grubs with brown heads, three pairs of legs on the thorax, and bodies an inch or so long when full-grown, which are curled in a half-circle. No method of control that can be applied satisfactorily in sugarcane fields is yet known.

The froghopper is found throughout sugarcane-growing sections of continental United States. They are sometimes fairly numerous during dry periods on sugarcane growing in well-drained soil. The nymph causes injury by sucking on the sugarcane stalks near the base, or slightly higher up behind leaf sheaths, where it surrounds itself with a conspicuous white, frothy mass. The adult is black with two fine red lines across the wings. The injury caused by this insect is not severe enough to justify control measures.

An oval, yellowish scale, with two reddish stripes down its back, *Pulvinaria iceryi* (Guerin), is sometimes found on sugarcane leaves in Florida and Georgia. This scale, when full-grown, is approximately 5 mm. long and 2 mm. wide. Another scale, *Aclerda holci* Teague, has been found on sugarcane in Louisiana. Since neither of these scales is important, no attempt has been made to find measures to control them.

The date mite is frequently found in Florida feeding on the underside of the sugarcane leaves and has caused noticeable injury in some fields. It is rarely important, however, and no control measures have been attempted.

The pink sugarcane borer is occasionally found in sugarcane in Louisiana and in southern Florida, but never in injurious numbers. The larva is pink and somewhat larger than the sugarcane borer. It apparently has only one generation a year.

Another borer, *Schoenobius* sp., has been observed in sugarcane stalks in Louisiana. In the middle of its body this borer is about the same size as the sugarcane borer but it tapers toward each end. Two purplish stripes run the entire length of its body. This borer, which also attacks rice, is of little economic importance.

A beetle larva determined as *Metamasius* sp. has been found attacking the root stocks and roots of sugarcane in Georgia and Louisiana. The larva of another beetle, or billbug, *Calendra cariosa* (Oliv.), has been collected feeding in seed cane in Louisiana. The adult of this billbug was found causing fairly severe damage to young sugarcane plants in southern Louisiana in the spring of 1949 following an unusually warm winter. The billbug inserts its beak in the young cane plant just above or beneath the ground level and eats out a section in the central part of the plant. As a result of this feeding the growing point dies and there is a dead heart similar to that found following sugarcane borer injury.

WARNING AGAINST MOVING UNTREATED SUGARCANE FROM ONE STATE TO ANOTHER

A number of the pests discussed in this circular now occur only in small portions of the Gulf coast sugar-producing area, but could easily be transferred to other sections through indiscriminate transportation of sugarcane. For this reason no cane should be moved from one section to another without first consulting plant quarantine officials.

Several States maintain regulations governing the movement thereto of sugarcane plants or parts thereof, and the interstate movement from parts of several southern States is also regulated by the Federal domestic plant quarantine on account of the white-fringed beetle. Most cane must be treated in one way or another to destroy any pests likely to be carried on or in it. Any pest thought to be new that is found attacking sugarcane, should be reported immediately to the State entomologist.

PRECAUTIONS IN THE USE OF INSECTICIDES

Cryolite, ryania, toxaphene, chlordane, and DDT are poisonous to man and animals, but with care they can be handled safely at strengths recommended for control of the various sugarcane insects. Avoid contamination of food and livestock feed. Thoroughly clean all vessels and tools used in handling these insecticides before using them for other purposes. Wash the hands and clothing thoroughly after handling any of the preceding insecticides. Store the insecticides in a dry place where children and animals will not have access to them.

LIST OF COMMON AND SCIENTIFIC NAMES OF INSECTS

Common Name	*Scientific Name*
Angoumois grain moth	*Sitotroga cerealella* (Oliv.)
Black cutworm	*Agrotis ypsilon* (Rott.)
Carrot beetle	*Ligyrus gibbosus* (Deg.)
Corn leaf aphid	*Aphis maidis* Fitch
Date mite	*Paratetranychus simplex* (Banks)
Fall armyworm	*Laphygma frugiperda* (A. and S.)
*Froghopper	*Tomaspis bicincta* Say
Granulate cutworm	*Feltia subterranea* (F.)
*Gray sugarcane mealybug	*Pseudococcus boninsis* Kuw.
Greenbug	*Toxoptera graminum* (Rond.)
Lesser cornstalk borer	*Elasmopalpus lignosellus* (Zell.)
*Pink sugarcane borer	*Merepleon cosmion* Dyar
Rusty plum aphid	*Hysteroneura setariae* (Thos.)
*Sedge aphid	*Carolinaia cyperi* Ainslie
*Sharp-nosed grain leafhopper	*Draeculacephala portola* Ball
Sugarcane beetle	*Euetheola rugiceps* (Lec.)
Sugarcane borer	*Diatraea saccharalis* (F.)
*Sugarcane weevil	*Anacentrinus subnudus* Buch.
*West Indian sugarcane fulgorid	*Saccharosydne saccharivora* (Westwood)
*West Indian sugarcane mite	*Tarsonemus bancrofti* Michael
Yellow sugarcane aphid	*Sipha flava* (Forbes)

*Name does not appear in list of Common Names of Insects Approved by the American Association of Economic Entomologists.

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